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Making Business Process Alignment measurable: A metrics-based evaluation lens for microservices decomposition

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Full Paper

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Abstract

Microservices architectures (MSA) are widely adopted to improve scalability and flexibility, yet their effectiveness depends on how well service boundaries reflect underlying business processes. Existing evaluation approaches primarily rely on structural and runtime metrics, providing limited insight into Business Process Alignment (BPA). This study proposes a criteria-driven, metrics-based evaluation framework that integrates established metrics with process- and capability-oriented indicators. Based on a systematic literature review, we derive a structured metric inventory and extend it with BPA-oriented metrics, including Process Step Coverage (PSC) and Business Capability Fidelity (BCF). The framework is demonstrated using two functionally equivalent prototypes: an ESB-based service-oriented architecture (SOA) and an event-driven MSA. The results show that BPA-oriented metrics reveal alignment differences not captured by conventional measures. The study operationalizes BPA as a measurable evaluation dimension and enables systematic comparison of architectural alternatives.

Keywords

Microservices Architecture, Business Process Alignment, Software Architecture Evaluation, Service Decomposition, Design Science Research, Enterprise Systems

Introduction

Microservices architectures (MSA) are widely used to decompose enterprise systems in pursuit of scalability, agility, and maintainability (Ayas et al., 2023). By promoting loosely coupled, independently deployable services, MSA promise faster evolution and organizational flexibility (Newman, 2015). However, these benefits critically depend on how service boundaries are defined. A central challenge in this context is Business Process Alignment (BPA), that is, the extent to which service boundaries reflect business processes and capabilities rather than purely technical structures.

Prior work shows that decomposition decisions are still often driven by technical dependencies and migration heuristics rather than explicit process logic, even though business-oriented decomposition is seen as essential for meaningful service boundaries (Ayas et al., 2023; Fritzsch et al., 2019). As a result, services may be technically modular but misaligned with end-to-end workflows, which can fragment business processes and increase coordination effort across service boundaries (Monteiro et al., 2020). Accordingly, prevailing evaluation practices focus on structural and performance metrics that provide limited insight into whether service boundaries preserve end-to-end business processes. While prior work has emphasized the importance of aligning MSA with domain models and business semantics, including domain-aligned modeling approaches (Fattah-Weil et al., 2026), explicit evaluation of Business Process Alignment remains limited. Although business processes are often referenced as design inputs (e.g., Evans, 2004; Fritzsch et al., 2019), explicit BPA evaluation remains rare. To address this gap, we propose a criteria-driven, metrics-based evaluation approach that complements established static and dynamic metrics with process- and capability-oriented indicators and demonstrate its discriminatory power using two functionally equivalent prototypes.

To guide this investigation, we address the following research questions:

- RQ1: What criteria and metrics are currently used to evaluate MSA decomposition, and to what extent do they capture BPA?
- RQ2: Which complementary metrics are required to make BPA observable and comparable in the evaluation of MSA decomposition?

Beyond introducing additional metrics, this study conceptualizes Business Process Alignment as an explicit and measurable architectural evaluation dimension, thereby extending existing MSA assessment frameworks with a business-semantic perspective.

Background and Related Work

This section provides the theoretical foundation for the study from two complementary perspectives. First, it explains why existing MSA decomposition and evaluation approaches often fail to capture business semantics and end-to-end process logic. Second, it positions BPA within architectural quality trade-offs to justify its treatment as an explicit evaluation dimension.

Limitations of Decomposition Approaches and Architectural Metrics in Capturing Business Semantics

MSA decomposition approaches span techniques like dependency-based clustering (Gysel et al., 2016), data-centric analyses, domain-oriented methods (Evans, 2004), and machine-learning-based inference (Ayas et al., 2023; Trabelsi et al., 2024). Despite these differences, most approaches optimize system-centric quality attributes including performance, scalability, and fault tolerance. Even when business concepts are considered, alignment with end-to-end processes is rarely evaluated explicitly.

Prior work shows that decomposition decisions that abstract from process structure can fragment workflows and increase orchestration effort (Koschmider, 2017). Traceability research further highlights missing links between business goals, process models, and service implementations, leaving alignment concerns implicit (Monteiro et al., 2020; Zimmermann et al., 2018). This limitation is reinforced by prevailing evaluation practices, which focus on structural and runtime metrics for example coupling, cohesion, granularity, and communication frequency (Taibi & Systä, 2019; Al-Debagy & Martinek, 2020). While these metrics enable reproducible comparisons of modularity and efficiency, they remain largely agnostic to business semantics and do not indicate whether services support coherent business capabilities or complete process steps (Hui et al., 2025; Trabelsi et al., 2023). Overall, BPA cannot be inferred from technical metrics alone and must be treated as a distinct evaluation concern.

Positioning BPA within Architectural Quality Trade-offs

Architectural design inherently involves trade-offs among quality attributes, and standards like ISO/IEC 25010 emphasize that suitability depends on context, stakeholder priorities, and expected evolution rather than absolute values (ISO/IEC, 2011). In MSA design, evaluation therefore cannot focus only on structural efficiency or runtime behavior, but must also consider whether service boundaries support business processes and organizational responsibilities. From this perspective, BPA represents an underexplored dimension within architectural quality trade-offs. Advances in observability may improve technical transparency, but they do not necessarily capture process integrity or alignment with business goals. Prior research therefore provides strong foundations for decomposition and technical evaluation, yet leaves a persistent gap: BPA is rarely assessed explicitly or systematically through metrics. This gap motivates a criteria-driven, metrics-based evaluation perspective that complements established structural and runtime measures with indicators linking service boundaries to business processes and capabilities.

Research Method

This study follows a Design Science Research (DSR) approach (Peffers et al., 2007) to develop and evaluate an artifact that enables the systematic assessment of BPA in MSA decomposition. DSR is appropriate as the study aims to design and evaluate an artifact. The Design Science Research Methodology (DSRM) structures the process into problem identification, objective definition, artifact development, demonstration, and evaluation.

Problem Identification and Objectives

The study is motivated by the observation that existing MSA decomposition evaluation approaches primarily focus on technical quality attributes (e.g. cohesion, coupling, and performance), while providing limited insight into whether service boundaries reflect end-to-end business processes and capabilities. The objective is therefore to develop an evaluation approach that integrates: (1) established static and dynamic architectural metrics, and (2) explicit BPA-oriented metrics to enable systematic and comparable assessment of MSA decomposition with respect to business process alignment.

Research process

The research process follows three steps: knowledge base construction, artifact development, and demonstration and evaluation. To ground artifact development, a systematic literature review (SLR) following vom Brocke et al. (2009) was conducted. Guided by Cooper's (1988) taxonomy, the review focused on studies connecting MSA with business process modeling, evaluation, and metrics. Relevant literature was identified through a structured search across IEEE Xplore, ACM Digital Library, Scopus, AIS eLibrary, SpringerLink, ScienceDirect, Wiley, and Google Scholar using combinations of the terms "microservices architecture," "business process," "evaluation," "metric," and "criteria." The resulting literature base informed the identification of existing evaluation approaches and BPA-related gaps. Based on these insights, a criteria-driven evaluation artifact was developed through synthesis of existing metrics and their extension with BPA-oriented evaluation dimensions. The artifact integrates multiple categories of evaluation metrics to support a comprehensive assessment of MSA decomposition. To demonstrate and evaluate its applicability, the artifact was applied to two functionally equivalent system prototypes implementing the same business process: one based on a Service-Oriented Architecture (SOA) and one on a MSA. Both systems were evaluated under comparable conditions to illustrate how the artifact supports the identification of differences in business process alignment across architectural alternatives. Table 1 summarizes the metric inventory derived from the literature and serves as the design knowledge base for the artifact.

	Metric	Definition	Source / Rationale
Static (Design-Time) Metrics	Coupling Between Services (CBS)	Number and complexity of inter-service dependencies	Taibi & Systä (2019); Al-Debagy & Martinek (2020)
	Cohesion (COH)	Internal functional coherence of service responsibilities	Tapia & Gaona (2023)
	Granularity (GRA)	Relative size and responsibility scope of service logic	Hassan et al. (2022)
	Redundancy (RED)	Degree of code or logic duplication across services	Cao & Zhang (2022); Oumoussa & Saidi (2025)
Dynamic (Run-Time) Metrics	Frequency of Inter-Service Calls (FIC)	Calls exchanged between services during a single process execution	Taibi & Systä (2019)
	Performance (PER)	End-to-end response time and latency under load	Hui et al. (2025)

	Scalability (SCA)	Ability of services to scale independently under varying workloads	Newman (2015)
	Traceability (TRA)	Visibility of end-to-end process execution across service boundaries	Hui et al. (2025)
BPA–Process/Capability Alignment	Process Step Coverage (PSC)	Coverage of BPMN-defined process steps by services	Proposed – BPMN-based process coverage
	Business Capability Fidelity (BCF/ABC)	Degree to which services map to defined business capabilities without overlap	Özkan et al. (2025); Drieschner et al. (2023); Zimmermann et al. (2018)
	Process–Goal Coherence (PGC)	Alignment between service logic and explicitly defined business goals	Zimmermann et al. (2018)
BPA–Change/Evolution Impact	Change Impact Scope (CIS)	Number of services affected by a defined business process change	Chen et al. (2023)
	Evolution Support (EVS)	Ease of adapting services to changes in business logic	Hui et al. (2025)
	Maintainability (MAI)	Modifiability of services in response to process changes	Lenarduzzi et al. (2020)
BPA–Coordination/Execution	Orchestration vs. Choreography (ORC)	Centralized versus decentralized process execution pattern	Monteiro et al. (2020)
	Process Completion Traceability (PCT)	Extent to which a full business process instance can be traced end-to-end in runtime logs	Hui et al. (2025); Tapia & Gaona (2023)

Table 1. Metrics Inventory for MSA Decomposition Evaluation (Static, Dynamic, and BPA)

Results

Design: Criteria and Metrics for Evaluating Business Process Alignment

The core artifact of this study is a criteria-driven, metrics-based evaluation framework designed to make BPA observable and comparable in MSA decomposition. The artifact is derived from a structured synthesis of existing evaluation approaches identified in the literature review and extends them with explicitly process-oriented metrics.

Artifact Overview

The artifact integrates static, dynamic, and BPA-oriented metrics to assess structural quality, runtime behavior, and business process alignment. Figure 2 illustrates the conceptual structure of the artifact and its links to BPMN models and business capability maps.

Derivation of Evaluation Criteria

The literature review showed that BPA remains largely implicit across existing approaches, motivating its explicit inclusion in the artifact.

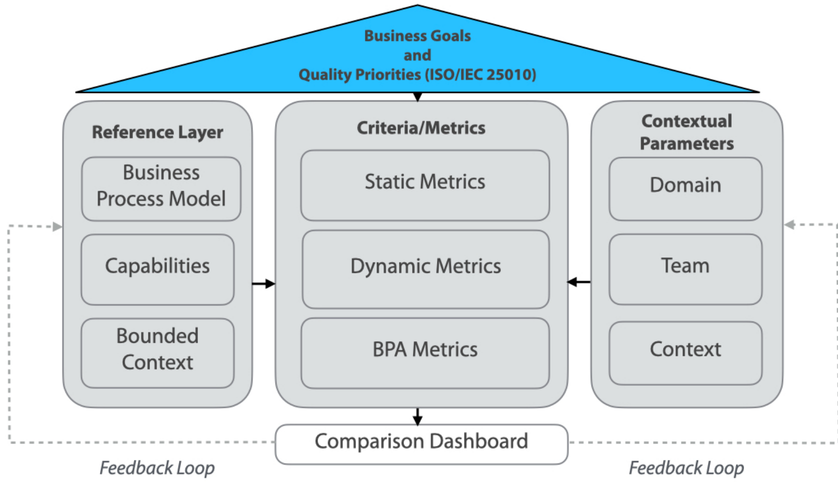

Figure 2. Analytical View of Metric Categories and Reference Artifacts used for BPA Evaluation

Metric Inventory

Table 1 summarizes the identified metrics and serves as the design knowledge base for the artifact. Metrics related to long-term evolution or runtime coordination were not retained in the core artifact because they were not sufficiently operationalizable in the controlled evaluation setting, but remain relevant for future extensions.

BPA-oriented Metrics

Three BPA-oriented metrics are introduced: Process Step Coverage (PSC), measuring the proportion of BPMN-defined process steps supported by services; Business Capability Fidelity (BCF), assessing the consistency between services and business capabilities; and Process–Goal Coherence (PGC), evaluating the extent to which service logic supports defined business goals. Together, these metrics extend existing evaluation approaches by introducing a business-semantic perspective, enabling the assessment of whether service boundaries reflect meaningful process and capability structures rather than purely technical decomposition decisions.

Artifact Contribution

The artifact contributes by integrating structural, runtime, and process-oriented evaluation dimensions, operationalizing BPA as a measurable construct, and enabling systematic comparison across architectural alternatives. This design forms the basis for the subsequent demonstration and evaluation, where the artifact is applied to compare two architectural alternatives.

Demonstration and Evaluation

To demonstrate and evaluate the applicability of the proposed artifact, we apply the criteria-driven evaluation framework to two functionally equivalent system implementations of the same BPMN-based reference process. One system follows a centralized Service-Oriented Architecture (SOA) with an ESB-based orchestration, while the other is realized as an event-driven MSA aligned to bounded contexts.

Demonstration Setup

Both prototypes were developed in this study from the same business process model, ensuring functional equivalence while differing in architectural realization: an ESB-orchestrated SOA and an event-based MSA. Supplementary materials and prototype artifacts are available at https://osf.io/5hqt3/?view_only=d5d7316c30c74f4394912d185b9f78b7. This setup enables a focused comparison of architectural alignment outcomes. The evaluation is based on three artifact types: a BPMN reference process, a business capability model, and implementation artifacts including services, interfaces, and runtime logs.

Operationalization of Metrics

From the overall metric inventory, two BPA-oriented metrics were selected for empirical application: Process Step Coverage (PSC) and Business Capability Fidelity (BCF), as they can be directly derived from process models and capability mappings. PSC was operationalized by mapping each BPMN process step to the service responsible for executing or coordinating the corresponding functionality and calculating the proportion of covered steps; manual steps were analyzed separately. BCF was assessed by assigning services to predefined business capabilities and evaluating overlap and fragmentation across service boundaries.

To ensure transparency and reproducibility, BPMN tasks were mapped to services based on service interfaces, implementation logic, and observable runtime interactions. Where multiple services contributed to a process step, the step was assigned to the service responsible for the primary business action, while supporting interactions were documented separately. Business capabilities were derived from the process model and assigned based on primary responsibility and ownership of business logic; services contributing to multiple capabilities were treated as overlap. The mapping was performed iteratively and validated against implementation artifacts such as service interfaces and logs. Static metrics (e.g., cohesion, granularity, coupling) and dynamic metrics (e.g., response time, throughput, error rates) were computed to provide contextual baseline information. The evaluation results are summarized in Table 2 and visualized in Figures 3 to 5.

	Metric	Operationalization / Data Source	SOA value	MSA value	Purpose / Interpretation
Static (Design-Time)	LCOM (Average Lack of Cohesion)	Computed per service and averaged.	0.34	0.34	Nearly identical; both decomposed via DDD, confirming semantic consistency in cohesion.
	Service Granularity Metric (SGM)	Weighted mean of functional and data granularity.	0.76	0.68	SOA's coarse-grained design inflates granularity; MSA finer-grained and more modular.
	Message Coupling Index (MCI)	Derived from dependency matrix of inter-service calls.	≤ 1.33	≤ 0.60	MSA shows markedly lower inter-service coupling; ESB causes dependency clustering in SOA.
Dynamic (Run-Time)	Average Response Time (ms)	Benchmark under four load scenarios (k6/JMeter).	80.75	53.21	MSA responds ~34 % faster; reduced orchestration overhead via asynchronous communication.
	P95 Response Time (ms)	Load test 95th percentile latency.	1 235	187	MSA maintains far lower latency under load; SOA bottlenecks under ESB congestion.
	Throughput (tx/s)	Requests processed per second.	22.13	38.70	MSA achieves ≈ 75 % higher throughput under equivalent conditions.
	Error Rate (%)	Failed requests per total calls.	61.73 %	0.01 %	SOA fails under stress due to ESB overload; MSA maintains stability under scaling.
Business Process	Process Step	Ratio of BPMN steps covered by	67 % (73 % excl.	72 % (79 % excl. manual)	MSA covers more process steps end-to-end; stronger linkage to BPMN reference model.

Oriented (BPA)	Coverage (PSC)	services to total modeled steps.	manual)		
	Alignment to Business Capabilities (ABC/BCF)	% of modeled capabilities realized by services.	67 % (78 % excl. manual)	73 % (84 % excl. manual)	MSA exhibits higher semantic alignment with business capabilities and activities.
Contextual (Development)	Development Effort (Commits)	GitLab repository commits.	99	198	MSA involved twice as many commits (iterative configuration and testing).
	Lines of Code (LoC)	Static code count.	15 957	16 288	Similar overall code size; MSA slightly larger due to service boilerplate and configuration.
	Containers (Docker Services)	Number of independent deployed containers.	5	9	MSA deployment more modular; each microservice deployed independently for scalability.

Table 2. Metric-Based Comparison of SOA and MSA

Static metrics showed only minor differences between the two architectures, reflecting their shared domain-driven decomposition logic. The SOA exhibited slightly higher coupling due to centralized orchestration, while the MSA showed finer-grained service structures. Dynamic metrics revealed clearer differences. The MSA achieved lower response times and higher throughput, while maintaining stability under increasing load. In contrast, the SOA showed performance degradation and higher error rates due to orchestration bottlenecks. The most pronounced differences emerged in the BPA-oriented metrics. The MSA achieved higher values for both Process Step Coverage and Business Capability Fidelity, indicating a closer alignment with the underlying business process and capability structure.

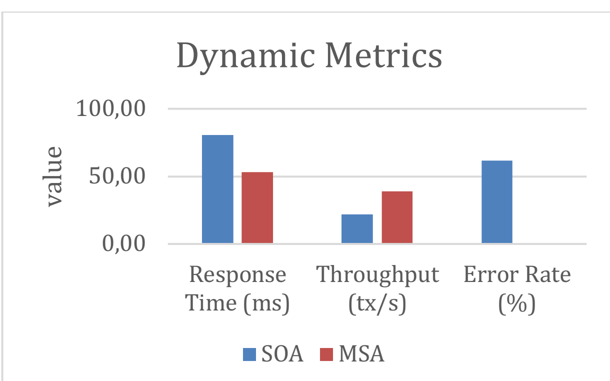

Figure 3: Dynamic Metrics Comparison (SOA vs. MSA)

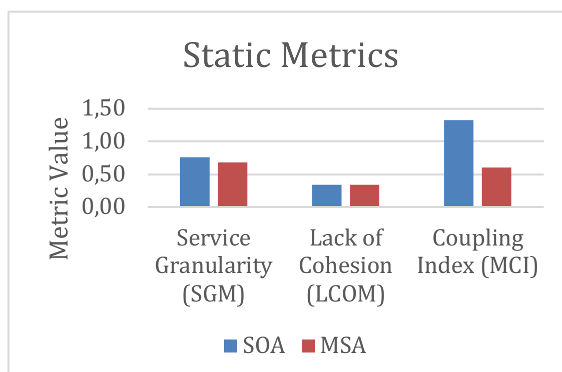

Figure 4: Static Metrics Comparison (SOA vs. MSA)

Evaluation

Conventional static and dynamic metrics provide limited insight into Business Process Alignment. While they capture structural quality and runtime behavior, they do not reveal how well service boundaries correspond to business processes and organizational responsibilities. In contrast, the BPA-oriented metrics introduced in this study provide interpretable indicators of alignment quality and differentiate between architectural alternatives even when traditional metrics suggest similar technical quality. At the same time, the findings must be interpreted within the constraints of the evaluation setup. The use of controlled prototypes ensures internal validity but limits external generalizability. The results therefore demonstrate analytical applicability rather than empirical generalization.

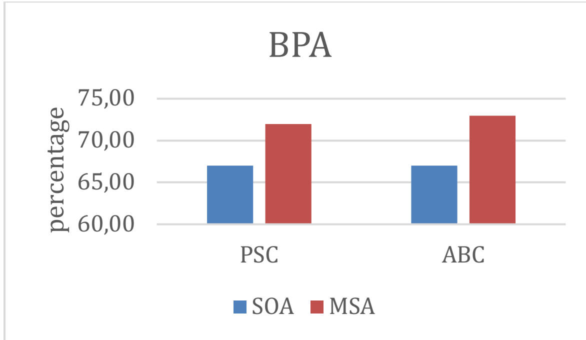

Figure 5: BPA Outcome Metrics Comparison (SOA vs. MSA)

Discussion

Evaluation Metrics and Their Ability to Capture BPA (RQ1)

The results confirm that existing evaluation approaches for MSA are predominantly grounded in structural and technical metrics. Prior studies from Taibi and Systä (2019) and Al-Debagy and Martinek (2020), emphasize cohesion, coupling, and granularity as key indicators of architectural quality, while runtime-oriented research focuses on performance, scalability, and communication overhead.

While these metrics provide valuable insights into internal system properties, they remain largely agnostic to business semantics. As also highlighted in process-oriented research (e.g., Zimmermann et al., 2018; Monteiro et al., 2020), the relationship between service boundaries and business processes is often implicitly assumed rather than explicitly evaluated.

The findings of this study support this observation. In the comparative analysis, the static metrics (e. g. cohesion and granularity) showed only marginal differences between the two architectures, despite clear differences in how business processes were represented. Dynamic metrics revealed relevant runtime trade-offs but did not provide direct evidence of alignment with process structures or organizational capabilities. In contrast, BPA-oriented metrics, particularly Process Step Coverage and Business Capability Fidelity, explicitly captured alignment differences that remained invisible in traditional evaluations. This demonstrates that BPA cannot be reliably inferred from conventional architectural metrics and must be treated as a distinct evaluation dimension.

Systematic Assessment of BPA Using Evaluation Metrics (RQ2)

Building on these findings, the study shows that BPA can be systematically assessed through a targeted combination of structural, runtime, and process-oriented metrics.

The key contribution lies not in proposing a new decomposition approach, but in defining how alignment can be operationalized within evaluation. While prior research acknowledges the importance of business processes in decomposition decisions (e.g., Evans, 2004; Fritzsch et al., 2019), it rarely provides explicit mechanisms for assessing whether these considerations are reflected in the resulting architecture.

The BPA-oriented metrics introduced in this study address this gap by linking service boundaries to BPMN-modeled process steps and business capabilities. This enables a direct and reproducible assessment of alignment properties, transforming BPA from a conceptual design objective into a measurable construct.

Importantly, the results also show that BPA metrics complement rather than replace existing evaluation approaches. Static metrics remain essential for assessing modularity and structural quality, while dynamic metrics provide insights into runtime behavior and operational efficiency. BPA metrics extend this perspective by introducing a business-semantic layer, allowing for a more comprehensive evaluation of architectural alternatives.

Implications for Research and Practice

This study contributes to both research and practice by extending the evaluation of MSA with an explicit business process perspective. From a research standpoint, it advances the conceptualization of BPA as a distinct and measurable evaluation dimension. While prior work has emphasized business alignment primarily at a conceptual or design level, this study demonstrates how it can be operationalized through concrete metrics. The proposed criteria provide a foundation for future multi-dimensional evaluation frameworks, enabling systematic comparisons across decomposition strategies, domains, and architectural styles. In addition, the findings highlight the importance of distinguishing between business-aware design inputs and business-aware evaluation outputs, encouraging future research to assess alignment explicitly rather than assuming it from design intent.

From a practical perspective, the results underline the limitations of relying solely on technical metrics when evaluating MSA. Improvements in these dimensions do not necessarily imply better alignment with business processes and may conceal misalignments that lead to fragmented workflows, increased coordination effort, and reduced transparency. The BPA-oriented metrics make such alignment aspects visible and communicable by linking architectural structures to process models and business capabilities. This supports more informed decision-making and facilitates communication between technical and non-technical stakeholders, particularly in enterprise contexts like ERP modernization, where business process continuity is critical. Rather than suggesting a universally superior architectural style, the findings emphasize that architectural suitability is context-dependent and that explicit BPA evaluation enables a more nuanced understanding of trade-offs.

Limitations and Future Research

This study has several limitations. First, the evaluation is based on controlled prototypes rather than large-scale industrial systems. While this enables a focused analysis of alignment effects, it limits generalizability; the results should therefore be understood as demonstrating analytical applicability rather than empirical generalization. Second, the operationalization of BPA metrics depends on the availability and quality of process models, capability maps, and system artifacts, which may be incomplete or inconsistent in real-world settings. Third, the study applies only a limited set of BPA metrics that can be operationalized in a controlled environment. Other relevant dimensions, such as long-term evolution, organizational change, or coordination complexity, were not included and remain important directions for future research. Future work should apply the proposed metrics in industrial case studies, explore automated tool support, and investigate links between BPA metrics and business outcomes after deployment.

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